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A New Species of Toad (Anura: Bufonidae) From the Lowlands of Eastern Guatemala

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ABSTRACT A new species of toad is described from the lowlands of eastern Guatemala. This species occurs sympatrically with *Bufo valliceps* but is restricted to low elevation, montane, rain forest where it apparently breeds in small streams; it does not occur in the disturbed areas, where *B. valliceps* is most abundant. The range of this species includes the low montane regions of eastern Guatemala, and the Maya Mountains of Belize. This species is placed in the poorly defined *Bufo valliceps* group.

Key words: Anura; Bufonidae; *Bufo campbelli; Bufo valliceps;* Guatemala; Belize.

RESUMEN Se describe una especie nueva de las tierras bajas del oriente de Guatemala. Esta especie ocurre simpátricamente con *Bufo valliceps* pero está restringida al Bosques Tropical Perenifolio de las montañas bajas y se reproduce en riachuelos pequeños; no ocurre en las áreas pertubadas por el hombre, donde *B. valliceps* es más abundante. La distribución de esta especie incluye las áreas de montañas bajas de Guatemala oriental y las Montañas Maya in Belice. Se ubica a esta especie en el pobremente definido grupo *B. valliceps* .

Palabras claves: Anura; Bufonidae; *Bufo campbelli; Bufo valliceps;* Guatemala; Belize.

Although Guatemala is a small country and the herpetofauna has been summarized twice in the past three decades (Stuart, 1963; Campbell and Vannini, 1989), it is a topographically complex area from which undescribed amphibians and reptiles continue to be discovered (e.g., Campbell and Brodie, 1988; Campbell and Smith, 1992; Brodie and Savage, 1993). The herpetofauna of the rain forests of the eastern lowlands has

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been poorly sampled until recent field work there in the Montañas del Mico by J. A. Campbell and the Sierra de Santa Cruz by E. N. Smith. These collections and others from the region (Duellman, 1963; Mendelson, 1990) have resulted in the collection of a distinctive new species of *Bufo* that had been collected syntopically with, and confused with, *Bufo valliceps*.

MATERIALS AND METHODS

Terminology of the cranial crests is modified from that of Martin (1972) and is shown in Figure 1. The webbing formula is that of Savage and Heyer (1967) as modified by Myers and Duellman (1982). Specimens with conspicuous nuptial excrescences on the first finger were assumed to be males; the sex of all specimens lacking such excrescences was determined by direct observation of the gonads.

The following morphometric measurements were taken in a manner following Duellman (1970:fig. 2): snout-vent length (SVL); tibia length

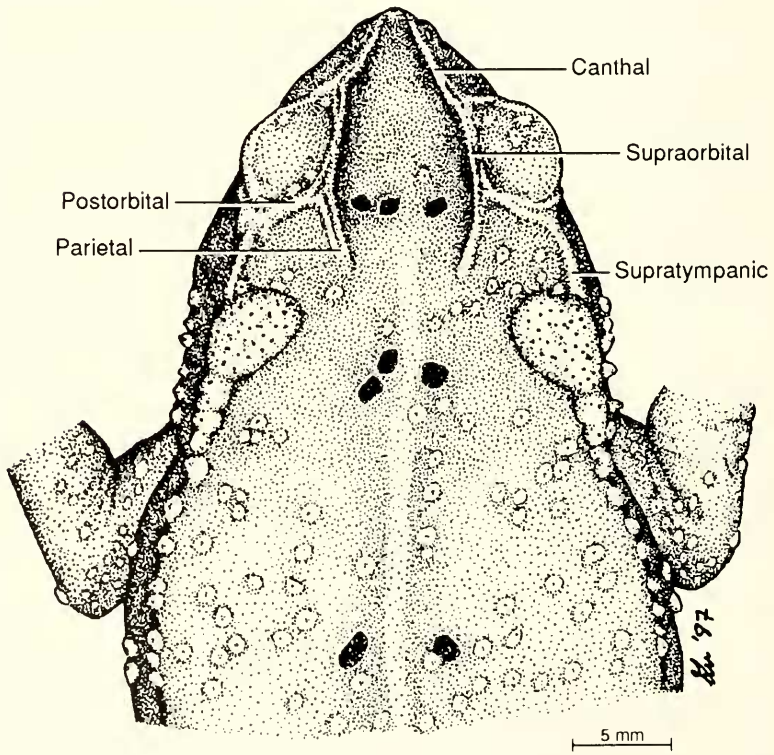

Fig. 1. Dorsal view of cranial area of *Bufo campbelli* (UTA A-18199, paratype) showing crest nomenclature used in this study; facial crests are shown in Figure 4.

(TIB); foot length (FT); head length (HL); head width (HW); tympanum diameter (TYMP). The following are additional, or modified, measurements: orbit (ORB; internal distance between bony margins of orbit); posterior crest width (PCW; distance between the lateral edges of supraorbital crest, taken from anterior side of junction with postorbital crest); anterior crest width (ACW; as above, taken from posterior side of junction with preorbital and canthal crests); eye-nostril distance (END; distance from posterior edge of bony margin of orbit to posterior margin of nostril); supratympanic crest (SPTYMP; straight distance between anterior and posterior margins of supratympanic crest; this measurement includes some component of the thickness of the postorbital crest); Finger I length (F1; distance from medial edge of pollical tubercle to tip of digit); Finger III length (F3; distance from fleshy base between second and third fingers to tip of digit); parotoid gland length (PARL; straight distance from most anterior point to most posterior point of gland); parotoid gland width (PARW; straight distance across gland, taken near the midpoint along its length and oriented perpendicular to the longitudinal axis of the animal).

A subsample of the toads identified in museum collections as *Bufo valliceps* from eastern Guatemala is distinctive by having relatively smooth skin, pointed snouts in dorsal and lateral profile, and the absence or very weak development of the preorbital and pretympanic crests relative to other specimens from the same area. Based on these easily observed qualitative characters, I separated all adult specimens into two groups. I labeled these groups simply "Blunt-nosed" and "Sharp-nosed" and compared them in an initial analysis using univariate (ANCOVA; BIOM package, Rohlf, 1985) statistics.

The initial diagnosis will serve to distinguish the new species from the sympatric population referable to *Bufo valliceps*. I performed a Principal Components Analysis (PCA) of the 15 variables described above to illustrate variation in the new species and variation among populations referable to *B. valliceps* from throughout most of the range of that species (Porter, 1970). Measurements used in this PCA were collected using digital calipers, rounded to the nearest 0.1 mm, and log-transformed. The analysis was run on a covariance matrix using the program Minitab (DOS Ver. 8; Minitab Statistical Software, 1991).

SYSTEMATICS

A total of 89 specimens of *Bufo* from the Department of Izabal, Guatemala, was available for the initial analysis; because all collections were heavily male-biased, this analysis was restricted to males. Fifty-three specimens were referred to the "Blunt-nosed" group and 36 to the "Sharp-nosed" group. Comparison of the two groups using ANCOVA indicated

that the adjusted means of the groups differed in the following measurements: TIB, FT, HL, and TYMP ($F << 0.001$, df = 1, 86); the slopes of the two groups did not differ in these analyses ($F > 0.05$; df = 1, 85). The slopes of the groups did differ in the comparison of F1 ($F < 0.05$, df = 1, 85); adjusted means of the groups were not compared for this variable. The groups were not different in the comparison of HW (Table 1 and Figure 2A–D summarize and illustrate these analyses). Based on the qualitative and quantitative differences observed between the two groups, herein I describe the "Sharp-nosed" group as

Bufo campbelli nov. sp.
Figs. 1, 3–5

Holotype.—University of Kansas (KU) 186320 (original number JAC 5029), an adult male, from Las Escobas, 5.1 km W Puerto Santo Tomás, 104 m, Montañas del Mico, Departamento de Izabal, Guatemala, obtained on 20 June 1980 by J. A. Campbell.

Paratypes.—KU 190083–84; University of Texas at Arlington (UTA) A-18198–99, 21673, 21676, 33047, 33570–73, 33576, adult males and KU 190085, an adult female. All specimens are from the same locality as the holotype.

Referred specimens.—See Appendix.

Diagnosis.—A moderate-sized species of *Bufo* having the following combination of characters: (1) tympanum small, less than 50% width of orbit; (2) preorbital and pretympanic crests absent or weakly developed in large individuals; (3) tibia long, about 46% SVL; (4) feet long, about 46% SVL; (5) skin relatively smooth; (6) vocal slits present; and (7) snout acutely rounded in lateral view and pointed in dorsal view.

Bufo campbelli occurs sympatrically with *B. valliceps*, but may be easily distinguished by the following characters in *B. campbelli:* longer legs; smaller tympanum; preorbital and pretympanic crests absent; smoother skin; longer head; and snout acutely rounded in lateral view, pointed in dorsal view. *Bufo cavifrons* and *Bufo cristatus* are known only from the Sierra de Los Tuxtlas and the Sierra Madre Oriental, respectively, in Veracruz, Mexico, and are not sympatric with *B. campbelli* . These two species resemble *B. campbelli* somewhat in overall body proportions and in the absence of preorbital and pretympanic crests, but differ by having greatly hypertrophied supraorbital, postorbital, and parietal crests; *B. cristatus* also differs by lacking vocal slits.

Description of holotype.—Body robust; head slightly wider than long, width 38.1% SVL, length 37.0% SVL; snout sharply pointed in dorsal view, acutely rounded in profile, rostral keel distinct; top of head flat; canthal, supraorbital, postorbital, supratympanic, and parietal cranial crests

Table 1. Results of ANCOVA tests in morphometric comparisons of males of the "Sharp-nosed" and "Blunt-nosed" groups from the Department of Izabal, Guatemala (cf. text). SVL was used as the covariate in each test. *ns* = not significant.

Variable	df	Sum of squares	Mean squares	*F*-value
Tibia length				
Slope				
Among slopes	1	0.24	0.24	0.43*ns*
Sum group deviations	85	47.35	0.56	
Means				
Adjusted means	1	192.14	192.14	347.19***
Error	86	47.59	0.55	
Foot length				
Slope				
Among slopes	1	0.52	0.52	0.60*ns*
Sum group deviations	85	73.24	0.52	
Means				
Adjusted means	1	143.40	143.40	167.19***
Error	86	73.76	0.86	
Head width				
Slope				
Among slopes	1	0.01	0.01	0.01*ns*
Sum group deviations	85	81.26	0.95	
Means				
Adjusted means	1	2.32	2.32	2.45 *ns*
Error	86	81.26	0.96	
Head length				
Slope				
Among slopes	1	0.82	0.82	1.11*ns*
Sum group deviations	85	62.41	0.74	
Means				
Adjusted means	1	34.20	34.20	46.51***
Error	86	62.22	0.73	
Tympanum diameter				
Slope				
Among slopes	1	0.67	0.67	0.67*ns*
Sum group deviations	85	8.52	0.10	
Means				
Adjusted means	1	11.29	11.29	113.10***
Error	86	8.59	0.10	
Finger I length				
Slope				
Among slopes	1	1.80	1.80	4.76*
Sum group deviations	85	34.00	0.40	
Means				
Adjusted means	1	4.64	4.64	11.73
Error	86	34.00	0.40	

*$P \leq 0.05$.
**$P \leq 0.01$.
***$P \leq 0.001$.

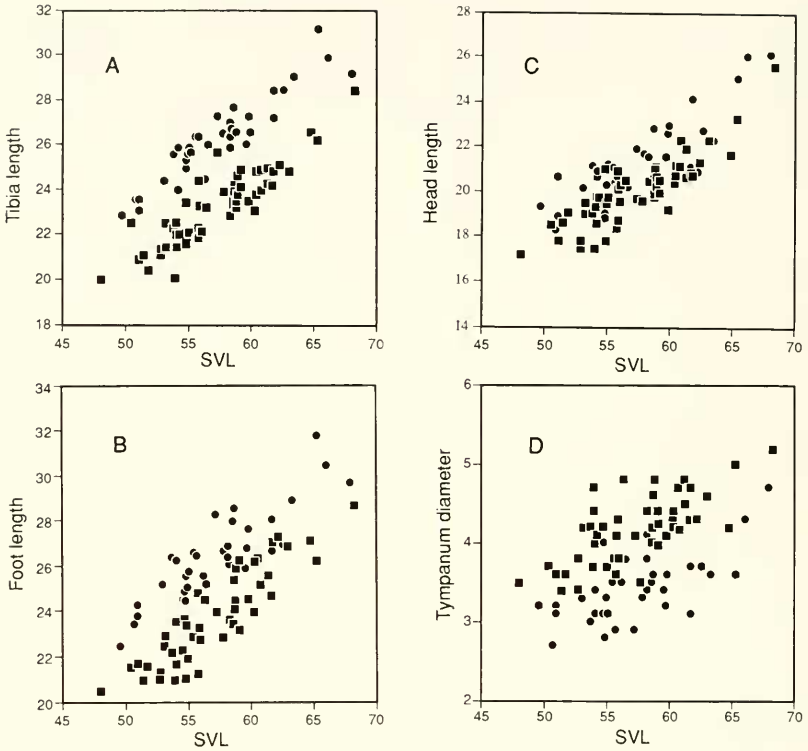

Fig. 2. Comparison of SVL and (A) tibia length, (B) foot length, (C) head length, and (D) tympanum diameter in the "Blunt-nosed" (squares) and "Sharp-nosed" (circles) groups of toads from Dept. Izabal, Guatemala. Some data points are superimposed. See Table 1 for statistics.

low and thin; preorbital, pretympanic crests absent; skin on top of head co-ossified with underlying cranial bones; upper eyelid 82.1% of interorbital distance; internarial area concave; nostril protuberant, directed dorsally; canthus rostralis forming distinct canthal crest; loreal region flat; lip rounded, with weak supralabial crest extending from level of anterior margin of orbit to corner of jaw; distinct V-shaped notch at symphysis of upper jaw; eye-nostril distance 63.6% diameter of orbit; tympanum distinct, slightly ovoid, width 85.9% of height, width 40.3% of orbit width, with raised annulus, upper margin contacting supratympanic crest. Forelimb long, slender; hand broad with long, slender fingers; relative lengths of fingers II < IV < I < III; webbing absent, lateral fringe on fingers indistinct; tips of digits slightly enlarged, smooth dorsally, demarcated proximally by distinct dermal fold; palmar tubercle distinct, large, triangular, low, flat; pollical tubercle smaller than palmar tubercle, distinct, round,

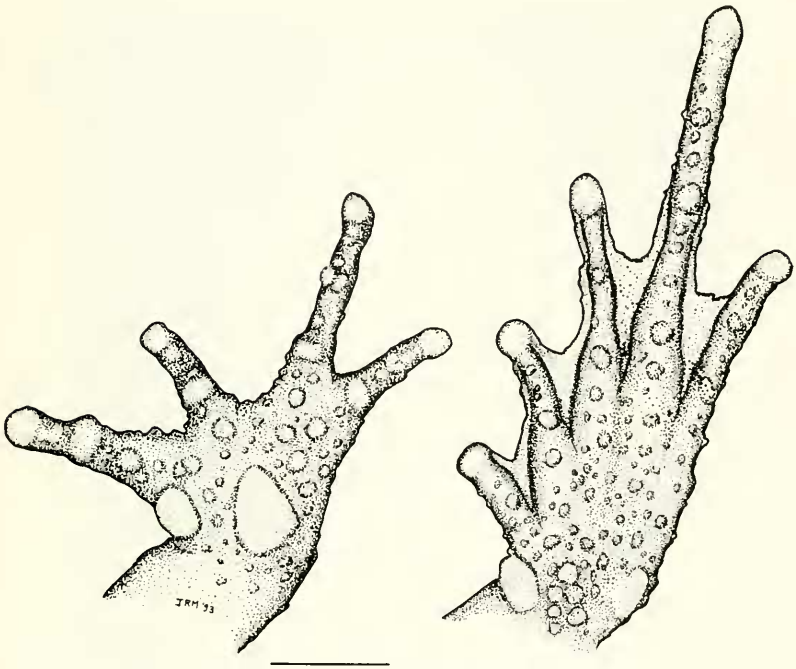

Fig. 3. Ventral aspect of the hand and foot of *Bufo campbelli* (holotype). Scale bar represents 5 mm.

low, flat; subarticular tubercles distinct, ovoid, elevated, angled distally, single, except distal tubercles paired on Digits III and IV; supernumerary tubercles distinct, elevated, round, scattered evenly on palm and fingers; thumb with thickened pad dorsally, nuptial excrescences absent. Hind limbs long, slender; tibia length 43.6% SVL; feet large; foot length 43.5% SVL; tarsal fold absent, replaced by a row of distinctly enlarged, sharply conical, tubercles; outer metatarsal tubercle small, low, ovoid; inner metatarsal tubercle larger than outer metatarsal tubercle, raised, ovoid; toes long, slender; relative length of toes I < II < V < III < IV; webbing thin, lateral fringe weak, present on both sides of all toes; webbing formula I 3—2^- II 3—2 III 3½—2^+ IV 2—2^+ V; tips of digits slightly enlarged, smooth dorsally, demarcated proximally by distinct dermal fold; subarticular tubercles distinct, round, raised; supernumerary tubercles variable in size, distinct, distributed evenly over ventral surface of foot, toes, except small cluster of larger, diffuse, flat tubercles on ventral surface of heel.

Skin on dorsum of body smooth with few, scattered, diffuse, low tubercles, becoming smooth with scattered, raised, conical tubercles laterally, some with weakly keratinized apices; lateral row of tubercles distinct,

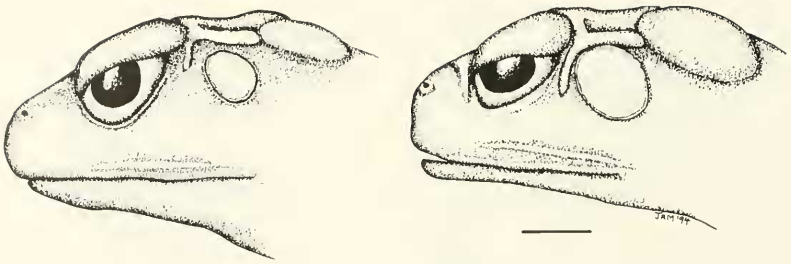

Fig. 4. Comparison of the lateral aspect of the head of male *Bufo campbelli* (left: holotype) and *Bufo valliceps* (right: UTA A-7429), showing differences in snout shape, tympanum size and position, and development of the facial crests (preorbital and pretympanic). Scale bar represents 5 mm.

slightly conical; dorsum of head smooth; loreal and tympanic regions weakly granular; eyelids with few, small, conical tubercles with weakly keratinized apices; small cluster of distinct, raised, weakly conical tubercles at corner of jaw; parotoid glands smaller than eyelids, low, flat, triangular; venter, throat, and flanks granular; dorsum of forelimbs, hands, hind limbs, and feet covered with fine, conical tubercles, becoming smoother laterally and on ventral surfaces.

Choanae small, subcircular, widely separated; teeth absent; tongue elongately ovoid, widest posteriorly, about twice as long as wide, free behind for almost one-half its length; vocal slits small, located medially, extending from level of posterior base of tongue posterolaterally to level of angle of jaw; vocal sac not distended, apparently single, median, subgular.

Coloration in preservative: Dorsum of body and head pale brown with few, small, paired black markings, becoming pale gray-brown dorsolaterally; lateral row of tubercles cream with distinct black stripe adjacent ventrally; lateral surfaces gray-brown becoming marbled with pale yellow on flanks; axilla pale yellow; loreal region pale brown; tympanic region and tympanum brown; pale yellow bar extending from posterior margin of orbit ventrally to margin of upper lip, bordered posteriorly by narrow black stripe; cluster of tubercles at corner of mouth cream; dorsal surfaces of arms, thighs, and tarsi brown, each with one irregular darker brown bar, bordered by narrow black stripes; dorsal surfaces of feet brown with two such bars, becoming yellow distally with irregular dark brown marbling, toe tips pale yellow; dorsal surfaces of hands brown becoming pale yellow distally on Digits I and II, other finger tips distinctly pale yellow; venter of belly dull yellow with heavy, indistinct, dark gray marbling; throat and pectoral area dark gray with pale yellow raised granules; ventral surface of thighs dull yellow with distinct fine black marbling;

Fig. 5. *Bufo campbelli* in life. Male (upper: UTA A-17174) and subadult female (lower: UTA A-18196) from the type locality, showing sexual differences in color and pattern.

ventral surfaces of hands black with all tubercles pale yellow; ventral surfaces of feet black with pale yellow subarticular, metatarsal tubercles, supernumerary tubercles black.

Coloration in life: Female (Fig. 5: UTA Color Transparency 1076):

Dorsal surfaces predominantly brown with an incomplete bluish-gray vertebral stripe, becoming gray laterally, dorsal markings charcoal black, dorsolateral tubercles and some intervening skin orange; tubercles at corner of mouth and lateral row of tubercles white; limbs brown with dark gray bar bordered by narrow black stripes and irregular bluish-gray markings; tympanic area and lateral surfaces ventral to lateral row of tubercles charcoal black; Digit II on hand and tips of all visible digits orange; iris dull bronze with black reticulations. Another female (UTA Color Transparency 1078) is similar but is more pale brown dorsally with a complete creamy brown vertebral stripe and lacks irregular black dorsal markings. Male (Fig. 5: UTA color transparency 12950): Dorsal surfaces pale greenish yellow with few, scattered, melanoid tubercles reddish brown; bars on visible limbs dark gray; thin line ventral to lateral row of tubercles black; highest portions of cranial crests black; iris dull bronze with black reticulations. Another male (UTA Color Transparency 12947) is similar, but lacks bar on visible forelimb and has a blood-red spot between upper lip and posterior margin of orbit.

Measurements of holotype (in mm): SVL 59.6, TIB 26.0, FT 25.9, HL 22.0, HW 22.7, END 5.4, ORB 8.5, TYMP 3.4, SPTYMP 4.5, PCW 8.5, ACW 6.5, PARL 6.7, PARW 4.3, F1 9.1, F3, 9.2.

Variation: The ranges of variation in morphometric variables of the male paratypes, and the female paratype are as follows (range, mean for males ± SD, followed by measurement of female in parentheses: SVL 49.6–62.6, 56.3 ± 3.7 (59.7); TIB 22.9–28.4, 26.0 ± 1.6 (27.7); FT 22.5–28.0, 26.0 ± 1.6 (27.4); HL 18.3–22.9, 21.2 ± 1.4 (22.5); HW 18.3–24.9, 21.7 ± 1.7 (24.7); ORB 7.2–9.0, 8.1± 0.6 (9.3); TYMP 2.7–3.7, 3.2 ± 0.3 (3.8); SPTYMP 3.2–5.2, 4.4 ± 0.5 (5.4); PCW 7.7–10.0, 8.9 ± 0.7 (11.0); ACW 6.0–7.8, 6.8 ± 0.4 (8.3); PARL 6.5–9.3, 7.6 ± 0.9 (8.5); PARW 3.5–4.9, 4.1 ± 0.4 (5.0); F1 8.1–10.4, 9.4 ± 0.6 (10.7); F3 8.4–10.8, 9.7 ± 0.7 (11.6).

The coloration (in preservative) of the male paratypes is similar to that of the holotype except the black line ventral to the lateral series of tubercles is absent in UTA A-21676, 33572. Unlike the holotype, all male paratypes have nuptial excrescences on the thickened pad on the dorsal and medial surfaces of the thumb, on the medial surface of Digit II, and on the medial surface of the pollical tubercle. The nuptial excrescences are black and finely granular, without conspicuous projections. The lateral tubercles are nonspinose in all males except UTA A-33047 in which they are weakly spinose. The vocal slits vary slightly in size and position among the paratypes. Most specimens are similar to the holotype, but UTA A-21676 has smaller slits located laterally, and KU 190083 and UTA A-18199, 21673 have smaller slits located medially.

The female paratype is generally similar to the male specimens in

coloration except the colors are much bolder. There are four distinct, asymmetrical black marking on the dorsum of the female and a dark black bar on the head, extending between the junctions of the parietal and supraorbital crests. The venter is more strongly mottled with dark gray markings than in the male series. The hind limbs of the female are more spinose than those of the males and the lateral tubercles are distinctly spinose.

Tadpoles.—The tadpoles of *Bufo campbelli* are unknown, despite considerable collecting efforts within its range. It is possible that they are indistinguishable externally from the tadpoles of *B. valliceps*.

Advertisement call.—The call of *Bufo campbelli* has not been recorded, but J. A. Campbell (Field Notes, 1 January 1987) gave the following account of UTA A-21676: "calling at 7 PM (immediately after dark), soft trill, in small pool fed by trickle of water off of main stream; very soft, hard to hear over stream."

Distribution and ecology.—Currently, *Bufo campbelli* is known only from the low montane regions of eastern Guatemala and the Maya Moun-

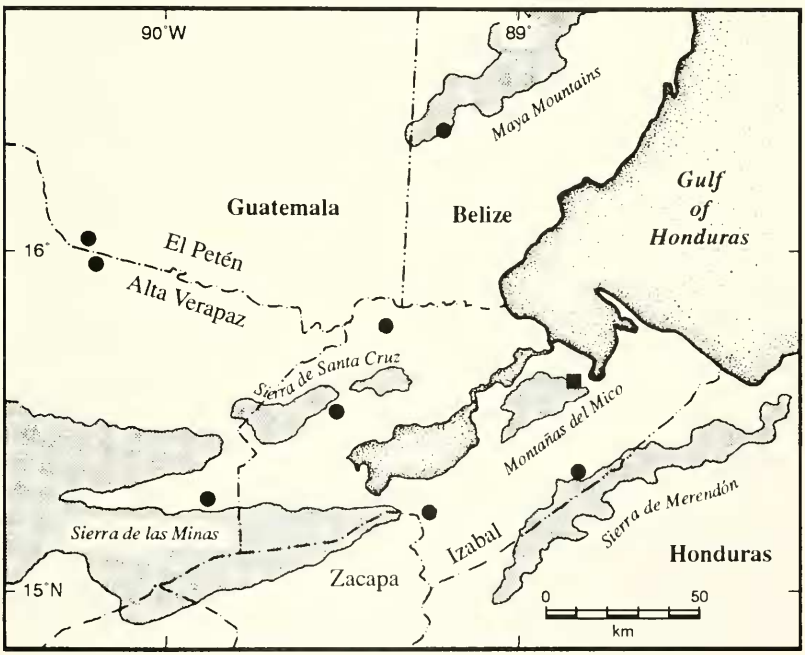

Fig. 6. Generalized map of the known range of *Bufo campbelli*. Closed circles represent localities where this species has been collected. Localities for *Bufo valliceps* are not shown, but this species is ubiquitous in disturbed habitat throughout the region. Approximate position of the 1000-m elevation contour is shown.

tains of Belize (Fig. 6). This species seems to be restricted to primary rain forest on low mountain slopes. It has been collected in such low mountain ranges as the Sierra de Santa Cruz and the Montañas del Mico, as well as in the foothills of the larger Sierra de Merendón and Sierra de las Minas. Duellman (1963) collected this species near Chinajá, Alta Verapaz/El Petén, Guatemala, along streams up to 10 km north of the escarpment of the Serranía de Chinajá, in lowland rain forest (Field Notes of W. E. Duellman, 24, 25 February 1960; 2, 15, 16 March 1960); this suggests that the species may follow stream habitats away from lower montane conditions. *Bufo campbelli* seems to be absent from the lower Polochic Valley, perhaps owing to conversion of this valley to pasture by humans, or it is possible that the low swampy conditions there may never have supported this species.

Bufo campbelli has been observed calling and in amplexus in small streams in virgin rain forest at the type locality (J. A. Campbell, pers. comm.). Individuals from the Sierra de Santa Cruz originated from primary forest in low montane areas, often along streams (E. N. Smith, pers. comm.). One specimen from the Sierra de Las Minas was found in a steep cardamom grove which was covered by a remnant primary forest canopy (Field Notes of J. R. Mendelson, 20 June, 1989). Although *B. valliceps* is grossly sympatric with *B. campbelli*, the former is abundant only in disturbed areas such as villages, pastures, cultivated areas, and various types of secondary growth; specimens listed as *B. valliceps* from primary forest at Pueblo Viejo (Mendelson, 1990) are in fact *B. campbelli*. *Bufo valliceps* in eastern Guatemala seems to breed in still pools, usually in disturbed areas (pers. obs.; J. A. Campbell, pers. comm.). The available information suggests that *B. campbelli* may breed primarily in streams in primary forest.

Etymology.—The specific epithet is a noun in the genitive case from the modern (unlatinized) name and is a patronym for Jonathan A. Campbell, in honor of his extensive efforts to document the herpetofauna of Guatemala, and to whom I am indebted for introducing me to the neotropics and encouraging my studies in these areas.

Remarks.—*Bufo campbelli* is broadly sympatric with a population of toads referable to *B. valliceps* and has consistently been catalogued into museum collections under this name. However, it is most similar morphologically to *B. cavifrons* and *B. cristatus* from Veracruz, Mexico. Both of these species occur in high elevation cloud or pine-oak forest. *Bufo campbelli* is distinct from these other species in occurring in lowland rain forest. The largest series of this species are from the Sierra de Santa Cruz and the Montañas del Mico, which are low ranges that do not support appreciable areas of cloud forest. A collection from the lower slopes of the high Sierra de las Minas (Mendelson, 1990) included *B. campbelli*, but

more extensive collections from the cloud forests in the Sierra de las Minas did not (Campbell, 1982).

Examination of referred specimens from throughout the known range of *Bufo campbelli* indicates the following consistent salient color characteristics: pale yellow digit tips, ventral surfaces of the shank, foot, and hand black, and distinctive pale yellow and black marbling on the posterior surface of the thighs. However, there is apparent sexual dimorphism in coloration in *B. campbelli;* males tend to be nearly unicolored dorsally, whereas females have more boldly contrasting patterns of black, browns, and grays, with distinct but variable black dorsal markings. Males usually have relatively smooth skin with nonspinose lateral tubercles and females have smooth skin with scattered, distinctly conical tubercles, more spinose hind limbs, and spinose lateral tubercles (Fig. 5).

A few specimens observed during this study seem to be slightly intermediate between *Bufo campbelli* and *B. valliceps* in appearance. Some specimens that I referred to *B. valliceps* (UTA A-8977, 24932–33, 28867, 28875, 28880) have slightly smoother skin and a more pointed snout in lateral profile than is usual for the species. Several others that I referred to *B. campbelli* (KU 55883, 55885–86) have slightly blunter snouts in lateral profile and a greater development of the facial crests than is typical for specimens of *B. campbelli* of their size. It is possible that these two species hybridize to some extent, perhaps in the disturbed areas in and around coffee fincas, where both species may be found. I have not seen any specimens that appear to be hybrids from near the type locality in the Montañas del Mico. Blair (1966) performed many laboratory crosses among species of the *B. valliceps* group and was able to produce fertile hybrid adults from some of the crosses. If these two species do hybridize, the resultant offspring are not distinct in appearance and are rare in collections from eastern Guatemala.

The ontogenetic development of the distinctive cranial crests of *Bufo valliceps* and many other Middle American species of *Bufo* has not been described adequately. Yet several taxa have been described based primarily on differences in the size or arrangement of these crests (e.g., *B. valliceps wilsoni* [Baylor and Stuart, 1961]; *B. valliceps macrocristatus* [Firschein and Smith, 1957]). Baylor and Stuart (1961) discussed the effect of the quality of preservation on the appearance of the cranial crests and reported that larger specimens (usually females) typically have hypertrophied crests. It is likely that dermal bone continues to be deposited onto the dorsum of the cranium in these species throughout their life; this trend and greater cranial ossification in females has been described in *Hyla septentrionalis* (Trueb, 1966; 1970). Porter (1964) stated that there is an increase in height of the cranial crests of *B. valliceps* associated with increase in elevation of the population, a claim taken directly from his dissertation (Porter, 1962: p.

24 and fig. 26). This work does not support the statement that crest height and elevation are positively correlated, but it does show a remarkable amount of variation in crest height in populations from near 1000 m in elevation. Porter's (1962) analysis is difficult to interpret because, apparently, he combined sexes in all of his analyses. Moreover, because Porter (1962) did not list specimens examined, I cannot verify the consistency of his taxonomy.

Because I have found no effective means of measuring many features of the cranial crests of these toads, most metric crest characters were excluded from these analyses. (SPTYMP, PCW, and ACW are exceptions, but see comment under SPTYMP above.) My observations indicate that the texture and thickness of the cranial crests (particularly the supraorbital, parietal, and postorbital) vary with size; thus, large females typically have the most hypertrophied crests in any given population. The diagnostic value of these features of the crests is not evident until their relation to size and age is better understood. It is likely that two populations of the same species may have different life-history patterns and growth curves (that well may vary with latitude and elevation), and that these differences are reflected in the apparently lifelong process of cranial ossification. It must be noted here that *Bufo cavifrons* and *B. cristatus* often are diagnosed by their grotesquely hypertrophied crests. Unlike the condition in some populations of *B. valliceps*, the hypertrophied crests are evident even in subadults of either sex; *B. cristatus* and *B. cavifrons* may also be diagnosed based upon other external characters and measurements.

Bufo valliceps is a wide-ranging (Porter, 1970, but see comments by Savage, *in* Frost, 1985) and variable species (Porter, 1962). The geographic variation in this species is in need of another thorough review to evaluate whether some populations warrant specific recognition; populations from eastern Guatemala apparently were not reviewed by Porter (1962). Thus, the task remains to establish that the toads that are sympatric with the new species are, in fact, conspecific with *B. valliceps*.

In Table 2, measurements of all adult male *Bufo campbelli* from Izabal and Belize are compared with those of the sympatric toad ("Blunt-nosed" group) from Izabal and those of several populations referable to *B. valliceps* (Porter, 1962; 1970) from a wide range of localities throughout the United States, Mexico, and Guatemala (Appendix). The type locality of *B. valliceps* is near the city of Veracruz, Veracruz, Mexico (Frost, 1985); I have included several series of specimens from lowland areas near this city in these analyses. The ranges of all measurements of the toad sympatric with *B. campbelli* in Izabal fall well within the range of the various *B. valliceps* populations (Table 2) and I cannot distinguish them based on any qualitative characters. The PCA conducted included all specimens included in Table 2.

Table 2. Comparison of measurements of male *Bufo campbelli* with *B. valliceps* from the Department of Izabal, Guatemala, and all male specimens of *B. valliceps* examined in this study (Appendix). Mean ± SD over range in parentheses; all measurements in mm.

	Species		
Variable	*B. campbelli* $n = 36$	*B. valliceps* $n = 53$	*B. valliceps* (all) $n = 205$
Snout-vent length (SVL)	57.4 ± 4.3 (49.6–68.0)	57.2 ± 4.0 (48.0–68.2)	59.7 ± 5.7 (48.0–74.6)
Tibia length (TIB)	26.3 ± 1.8 (22.9–31.1)	23.2 ± 1.7 (20.0–28.4)	23.4 ± 1.9 (19.7–28.4)
Foot length (FT)	26.5 ± 1.9 (22.5–31.8)	23.8 ± 2.0 (20.5–28.7)	23.9 ± 2.1 (18.6–29.7)
Head length (HL)	21.4 ± 1.8 (18.3–26.1)	20.0 ± 1.5 (17.5–25.6)	20.5 ± 1.9 (16.8–27.8)
Head width (HW)	22.5 ± 2.0 (18.3–26.9)	22.6 ± 2.0 (18.6–29.8)	23.2 ± 2.3 (18.6–29.8)
Interorbital distance (ORB)	8.3 ± 0.7 (7.2–10.4)	8.3 ± 0.5 (7.0–9.6)	8.5 ± 0.6 (6.8–10.1)
Tympanum diameter (TYMP)	3.4 ± 0.4 (2.7–4.7)	4.1 ± 0.4)(3.4–5.2)	4.1 ± 0.5 (2.8–6.0)
Supratympanic crest length (SPTYMP)	4.7 ± 0.7 (3.2–5.9)	4.5 ± 0.6 (2.9–6.0)	4.4 ± 0.6 (2.9–6.4)
Finger 1 length (F1)	9.5 ± 1.0 (8.1–11.8)	9.0 ± 0.8 (7.8–10.7)	9.0 ± 1.0 (5.6–11.6)

The first four principal components (PCs) accounted for 83.3% of the variation among the specimens included in this analysis. The eigenvalues, loadings, cumulative proportion of variation described, and hypothetical eigenvectors are presented in Table 3. The first PC seems to represent overall size and correlation of all variables with size. The second, third, and fourth PC's represent nonsize-correlated variation within the sample. The second PC has strong positive loadings for variables TIB, FT, SPTYMP, F1, and F3, and strong negative loadings for variables PCW, TYMP, and PARW. The third PC has strong positive loadings for HW and TYMP, and

Table 3. Partial results of the PCA (covariance matrix) performed on 15 morphometric variables taken from male specimens of *Bufo campbelli* and *B. valliceps*; only the first three of 15 PCs were analyzed. Loadings of each variable are shown (hypothetical eigenvectors in parentheses) below the cumulative proportion of variance.

Variable	PC 1	PC 2	PC 3
Eigenvector	0.0209	0.0046	0.0022
Proportion of variance	0.59	0.13	0.06
Cumulative proportion	0.59	0.73	0.79
Snout-vent length (SVL)	-0.25 (-1)	-0.08 (0)	0.05 (0)
Tibia length (TIB)	-0.20 (-1)	0.26 (1)	-0.09 (0)
Foot length (FT)	-0.23 (-1)	0.24 (1)	-0.13 (0)
Head length (HL)	-0.23 (-1)	0.11 (0)	-0.03 (0)
Head width (HW)	-0.27 (-1)	-0.02 (0)	0.11 (0)
Posterior crest width (PCW)	-0.29 (-1)	-0.13 (-1)	0.11 (0)
Anterior crest width (ACW)	-0.23 (-1)	-0.07 (0)	0.08 (0)
Interorbital distance (ORB)	-0.19 (-1)	-0.06 (0)	0.13 (0)
Eye-nostril distance (EN)	-0.23 (-1)	0.10 (0)	0.02 (0)
Tympanum diameter (TYMP)	-0.30 (-1)	-0.38 (-1)	0.64 (2)
Supratympanic crest length (SPTYMP)	-0.34 (-1)	0.30 (1)	0.20 (0)
Finger I length (F1)	-0.27 (-1)	0.29 (1)	-0.09 (0)
Finger III length (F3)	-0.20 (0)	0.31 (1)	-0.14 (0)
Parotoid gland length (PARL)	-0.32 (-1)	-0.12 (0)	-0.49 (-1)
Paratoid gland width (PARW)	-0.25 (-1)	-0.63 (-2)	-0.45 (-1)

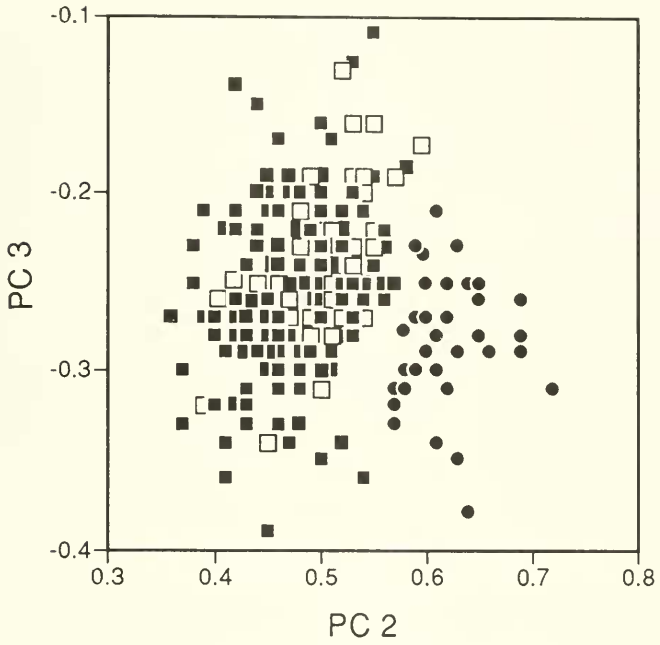

Fig. 7. Plot of individual scores on PC 2 and PC 3. Closed circles represent *Bufo campbelli*, closed squares represent *Bufo valliceps*, open squares represent *Bufo valliceps* from the Chinajá (El Petén/Alta Verapaz, Guatemala) area and Dept. Izabal, Guatemala (populations sympatric with *Bufo campbelli*). Some data points are superimposed. See Table 3 for results of the Principal Component Analysis.

strong negative loadings for PARL and PARW. The fourth PC has strong positive loadings for HL and ORB, and strong negative loadings for SPTYMP and PARL. Plots of the scores of individual specimens along these PCs are shown in Figure 7. From these plots, it is evident that *Bufo campbelli* is distinct from all populations of *B. valliceps* included in this study and that the population of toads with which it is sympatric in eastern Guatemala is indeed referable to *B. valliceps* based on this analysis. The fact that *B. valliceps* is a remarkably variable species is also evidenced by this figure. Although all populations of *B. valliceps* are coded alike in the figure, I noted during its preparation that there seem to be no consistent geographic trends in this species; intrapopulational variation was about the same as interpopulational variation.

This new species is a member of the Bufonidae based on the presence of the Bidder's organ and the absence of teeth. However, if one recognizes several bufonid genera (e.g., *Atelopluryniscus*, McCranie et al., 1989), the genus *Bufo* cannot be diagnosed. Nonetheless, this species is placed into the genus *Bufo* based on the presence of parotoid glands and cranial crests,

and the absence of other derived characteristics. There is no current consensus as to what characters define the *B. valliceps* group or which species should be included. However, based on the presence of a lateral descending series of tubercles and a full complement of cranial crests, *B. campbelli* is tentatively placed in the *B. valliceps* group (sensu Blair, 1972; Duellman and Schulte, 1992), pending better resolution of the phylogeny of *Bufo*.

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APPENDIX

Specimens examined and their localities. All specimens are preserved in fluid. Holotype and paratypes of *B. campbelli* are not included herein.

Bufo campbelli

Belize: *Toledo:* Maya Mountains, SW end Little Quartz Ridge, UTA A-8984–85.

Guatemala: *Alta Verapaz:* Chinajá, 140 m, KU 55901, 55909; N slope Sierra de las Minas, Finca Pueblo Viejo, Río Tinajas/Río Pueblo Viejo divide, 4.5 air km SSE Pueblo Viejo, 335 m, UTA A-28893; N slope Sierra de las Minas, Finca Pueblo Viejo, E slope Río Chiquito/Quebrada Cancoy divide, 7–7.5 air km SSW Pueblo Viejo, 731 m, UTA A-28897; vicinity of Pueblo Viejo, UTA A-33012. *El Petén:* 8 km NNW Chinajá, 120 m, KU 55875–77, 55882–86; 10 km NNW Chinajá, 120 m, KU 55888–90; 11 km NNW Chinajá, 120 m, KU 55898; 15 km NW Chinajá, 120 m, KU 55917. *Izabal:* Montañas del Mico, 7.8 km WSW Puerto Santo Tomás, UTA A-

18196–97; Montañas del Mico, Las Escobas, 5.1 km WSW Puerto Santo Tomás, 122 m, UTA A-18200, 21672, 33043–45, 33048, 33574–75, KU 186326, 186334; Montañas del Mico, 6.0 km WSW Puerto Santo Tomás, UTA A-21674–75; Montañas del Mico, 5.5 km WSW Puerto Santo Tomás, near Las Escobas, UTA A-24721; 0.8 km W Aldea Vista Hermosa, Los Amates, 500–950 m, KU 190086–87, 190134–136, 190138, 190140, 190151; Sierra de Santa Cruz, 10.0 km W Finca Semuc headquarters, Semococh, UTA A-24934, 24941, 26417; Sierra de Santa Cruz, ca. 4.5 km S Finca Semuc headquarters, UTA A- 24937–38; Sierra de Santa Cruz, Finca Semuc, UTA A-24940, 24944; Seshan, UTA A-26420–22; Sierra de Santa Cruz, Finca Semuc, 4 km W Finca Semuc headquarters, Seyamch, UTA A-26415; El Estor, Sierra de Santa Cruz, Finca Semuc, Cerro Sechoc, UTA A-33055, 33058; Sierra de Santa Cruz, 6.0 km S Franco, UTA A-33059–63; Sierra de Santa Cruz, Finca Semuc, 3 road km S headquaters, UTA A-33577, 33579–83; Municipio de Morales, Sierra de Caral, San Miguelito, 450 m, KU 221203.

Bufo valliceps

Mexico: *Campeche:* 7.5 km W Escarega, KU 71004, 71007, 71009, 71011–13, 71017, 71020–22, 71024, 71027–33, 71035. *Veracruz:* 12.8 km N Acayucan, KU 97672–73, 97675–85; Portrero Viejo, KU 25842, 25845, 25847–48, 25850–51, 26908; Cuatlapan, 97686; 16 km NE Fortín de las Flores, KU 97687, 97689–91, 97693–96; road between Catemaco and Sontecomapan, MZFC 5183–84, 5198, 5201–02, 5204–06. *Quintana Roo:* Pueblo Nuevo X-Can, KU 71037–38, 71041–50.

Guatemala: *Alta Verapaz:* 10.2 mi W Tucurú, UTA A-7418–28; N slope Sierra de las Minas, Finca Pueblo Viejo, along Río Chiquito, above Sechiquito village, 100 m, UTA A-28866–67; N slope Sierra de las Minas, Finca Pueblo Viejo, UTA A-28866–67, 28869–71, 28874–28876, 28878–80, 28885, 28894, 28898, 28936, 2900; Chinajá, KU 55902–08, 58375. *Izabal:* 1.8 km SW Morales turnoff on Hwy CA-9, 85 m, KU 190100–101; 4 km ENE Morales turnoff on Hwy CA-9, 85 m, KU 190102; Río Blanco, 120 m, KU 190098–99; 1.5 km N Rio Blanco, KU 58397–99; El Estor, Club Sechoc, UTA A-34048, 33578; Puerto Libre Hotel, at road fork between Puerto Santo Tomás and Puerto Barrios, UTA A-21677–78; Nickel Mine Airstrip at El Estor, UTA A-7429; 1.7 mi W El Estor, Las Dantas, UTA A-7430–31; Montañas del Mico, 1.4 km WSW Puerto Santo Tomás, near Las Escobas, UTA A-24738–39; Sierra de Santa Cruz, 10.0 km W Finca Semuc headquarters, Semococh, UTA A-24932–33, 24942; Montañas del Mico, 5.1 rd km WSW Puerto Santo Tomás, Las Escobas, UTA A-33046, 33049; Livingston, Aldea La Libertad, UTA A-33054; Livingston, km 250, hwy to Peten, UTA A-33052; Los Amates, Sierra del Espiritu Santo, Aldea San Antonio, UTA A-33065; Los Amates, Canaan–San Anto-

nio road, UTA A-33056; Chichipate, UTA A-26423; Los Amates, Aldea Vista Hermosa, KU 190133, 190137, 190141, 190146–47, 190152; Municipio de Morales, sierra de Caral, road between Quebradas and San Miguelito, 200 m, KU 221202. *El Petén:* 8 km NNW Chinajá, KU 55873–74, 55878–81; 10 km NNW Chinajá, KU 55887; 11 km NNW Chinajá, KU 55891–97, 55899; 16 km NNW Chinajá, KU 55900, 55910–16; 15 km NW Chinajá, KU 55918; N Uaxactun airstrip, KU 156390; Uaxactun, KU 156393–95; ca 4 mi N Poptun, KU 156396–97, 156400–01, 156403; 1 mi W Ruinas Ceibal, KU 156407–08; 1.9 mi S La Libertad, KU 156410–13; 8.6 mi W El Cruce, KU 156414–15; 34.6 mi E El Cruce, KU 156422; 3 mi S Tikal, KU 156416–20; 3.6 mi W Tikal, Lago Peten Itza, KU 156421. *Escuintla:* 7.7 km SSW Santa Lucia Cotzumalguapa, on road to Las Playas, UTA A-29009–14, 29016–20. *Retalhuleu:* 3.2 km N Champerico, UTA A-25849–60, 25864. *Santa Rosa:* 7.4 mi W Chiquimulilla, KU 97704, 97706–07, 97709, 97711–12.

USA: *Louisiana:* 4 mi S Baton Rouge, East Baton Rouge Parish, KU 22519, 22522–27. *Texas:* Brownsville, Cameron Co., KU 11604, 11607, 14309, 14314, 14316, 14318,–19, 14326, 14330.